A SURVEY OF USERS OF THERMAL SIMULATION PROGRAMS

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ABSTRACT

Much of the current building simulation research and development concentrates on improving user interfaces to simulation "engines". The goal seems to be to make the software easier to use. This begs two questions: what interface to use? And, by what criteria is software ease of use measured? What is the intelligent personal (design) assistant[1]? This paper reports analysis of a survey of users of simulation software which aimed to determine what they seek from improvements to the product they use regularly.

During January and February 1996 a telephone and mail survey was conducted of experienced simulation consultants in the western United States of America.

This paper examines the processes used by these practitioners when they wish to maintain quality assurance in their office simulation routine. It also describes the priority placed by these practitioners on such usability features as Graphic User Interfaces, Default Values and "Prototypical" buildings.

INTRODUCTION

This paper is based on two surveys. One conducted in New Zealand in conjunction with contract work to revise the Energy Efficiency Clause of the New Zealand Building Code[1] and the other conducted in the USA. For the New Zealand (NZ) Survey, the participants were approached in person and by telephone. The survey of USA users of simulation programs was conducted by telephone and mail.

The questionnaire format for the USA survey was based on the experience with the New Zealand survey. It was targeted at a more specialised audience.

For the purposes of these surveys "support tools" included (but were not solely limited to):

- technical tools - including nomographs (whether on paper or computerised), rules of thumb, handbooks, computer simulations, Standards, etc
- economic tools - calculation procedures, computer assistance, Standards etc.

The USA Survey of the energy simulation programs BLAST, DOE2 and SUNCODE was conducted in early 1996. The major questions addressed were:

- degree of expertise in the use of simulation packages in the design of buildings.
- The amount of customisation of the simulation package routinely undertaken.
- desired improvements to the simulation package.
- the types of analysis simulation is used for.
- perceived roles of the participants in a design team (architect, engineer, developer etc) in environmental design analysis.

Essentially, this survey sought to understand what are the expectations of the members of the design team for the roles they play in ECS design, and the potential involvement of simulation in these roles. It critically examines the architects' role in simulation in light of general agreement amongst simulationists that *intuition is not sufficient for good decision making* and that *energy conscious design alternatives* (should be considered) *as early as possible in the design process.*[2]

SURVEY DESIGN

In the pilot study for the NZ survey it became apparent that there was an important distinction between actions taken in order to comply with Clause H1 of the Building Code and those done for the sake of energy efficiency. As a result, the final form of the survey separated out questions regarding design tools for code compliance, and design tools for more general energy efficiency.

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[1]Negroponte, N, *Being Digital*, Alfred A Knopf, Inc, New York; 1995

After the NZ Survey the opportunity was taken to study the same questions in a broader international context. The West Coast of the USA was selected as it has long been a place where building simulation tools have been used in demonstrating compliance with local building codes. *Currently it is estimated that 80% of houses use the computer methods, and only 5% use the prescriptive packages*[3].

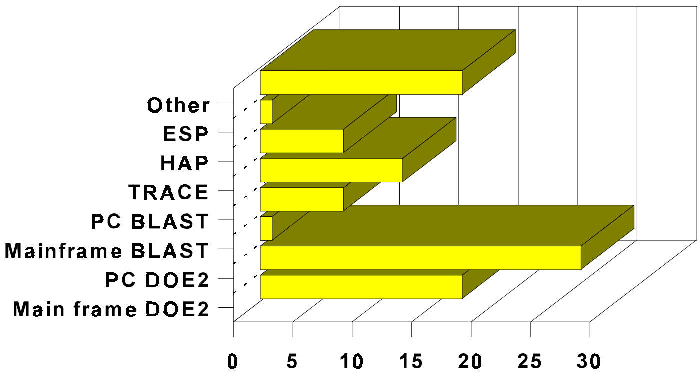

Figure 1 USA Survey: Computer programs used by the participants

In both surveys the target participants were users of building environmental design tools. However, in the NZ Survey, the goal was to look at the broad range of people involved in the building industry who might use environmental design tools. The engineer, architect and architectural designer categories of participant amounted to 50% of the total number of people surveyed.

For the USA Survey the goal was to identify a group of experienced users of these simulation tools and survey their experiences and attitudes. Ultimately the goal was to establish a specification for simulation based building design tools that support the building industry in its current practices and processes.

The NZ survey form contained 52 questions, and consisted of closely spaced type on seven A4 pages. The USA Survey contained 51 questions, on 23 A5 pages and was published as a small brochure.

Only 16 of the individual questions in each survey address the same issues. Of these, 9 are 'Scene setting" questions designed to establish the size and type of the participant's firm. The rest of the questions in the NZ Survey are addressed to issues of specific application to the NZBC project which funded the bulk of the work. The questions in the USA Survey address topics related to the usability and individual approaches to the use of computer simulation programs in the design of buildings.

PARTICIPANTS

In total the NZ Survey surveyed 82 people, 80 of whom participated. Of these, 28 were builders or developers, 12 were engineers and 27 were architects or building designers. The USA Survey of 399 postal forms and 22 telephone approaches resulted in 44 valid responses. Of those who entered data about their firm, 17 described their firm's *primary role in the building industry* as *HVAC Engineer*; 16 described themselves as *Simulationists*; and 5 said they belonged to a *Utility support group*.

Figure 1 shows the computer programs used by the 44 participants in the USA Survey. These numbers simplified to 2 *BLAST*, 11 *Other* and 30 *DOE2* regular users. 11% of the NZ Survey (24% of the USA Survey) respondents said that passive solar design always affects the design of their homes. Only 21% of the NZ Survey respondents said that they are always involved in the selection of energy efficient appliances. In the USA Survey, 75% of the participants are *always* or *sometimes* involved in the selection of energy efficient HVAC equipment.

The responses to the USA Survey allow categorisation of responses according to two basic types of firm: those who describe their firm's role in the building industry as *primarily HVAC Engineer* and those who see themselves as *Simulationists*. There is an even split in numbers between these two groups. This split seems to explain the separation of roles in answer to a question about involvement in passive solar design: a small minority of 4 of the HVAC engineers *Always* or *Frequently* become involved in projects where passive solar design features influenced design choices. By contrast, over half of the Simulationists become involved this often.

The US Survey participants are mostly involved in commercial office and retail building design. The responses *few* or *none* of our buildings are *domestic*, *hotel/motel* and *industrial* buildings were applied by 70-80% of participants. In the NZ Survey 20% of participants are involved only with domestic buildings; 55% are involved with a mixture of both commercial and domestic buildings; and the final 25% do no domestic buildings.

The USA Survey participants reported that they all use computers whereas 13% of the NZ Survey participants did not use computers.

COMPARATIVE ANALYSIS

All but two of the USA Survey participants responded to the question about training in the use of the simulation program they nominated. Almost all of them (88%) had received some training. One third had had formal training in a course. Over half had received *training* or at least assistance in learning from a *colleague*.

Although the topic of the New Zealand Survey question was more general, it is still instructive to compare the responses with those from the USA Survey. Only one third of the NZ participants had received any training. In fact, only one tenth of the participants had done any course on the design tools that they used to demonstrate compliance with the building code.

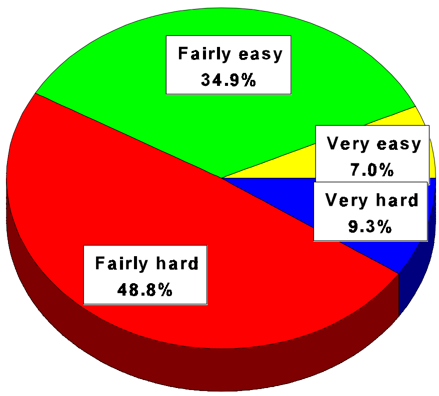

Figure 2 USA Survey: Ease of use of Simulation Program

From **Figure 2** we can see that the USA Survey participants are equally divided over the ease of use of the environmental performance simulation programs they employ in building design.

The final question in this set is the most revealing of general attitudes to design tools. In both the NZ and USA surveys, respondents were asked to describe what type of tool they would find helpful in *the production of more energy efficient buildings*.

The NZ Survey asked participants to express their preferences between *Checklists, Manual Calculations, and Computer Calculations*. The USA participants were asked to state how much they would use *Checklists Manual Calculations, Simulation* and *Case Studies*. While each response is coloured by the experience of each type of design tool, they do give a good indication of what medium is preferred for delivery of environmental design advice when actually working on the design of buildings. The USA Survey participants' responses have added value over those from the general building industry background of the NZ Survey because of their far greater direct experience of simulation program use.

The USA Survey participants liked all four of the options offered. The positive responses outnumber the negative. Very few see any of the types of design tool as *never* helpful. Savings estimators like charts and tables for use with calculators and their spreadsheets equivalents are least liked of the four options. However, a very high 79% of these participants responded that simulation programs would *help a lot* and *none* of them see such programs as *never useful*. The pre-selection of simulation experts seems to have found people who not only use simulation in their everyday practices, but also see a high value in continued and expanded use of simulation in building design.

The NZ Survey participants did not like the option of manual calculations - only two of the 13 engineers and two of the 30 architect/designers liked this type design tool. Five of the engineers and 17 of the architects preferred *Checklists*. Six of the engineers and 10 of the architects preferred *Computer Calculations.*

SURVEY OF SIMULATION USERS

Questions 20 through to 43 of the USA Survey were the most important part of either survey. That importance arises because they address directly the properties of current simulation programs and the way in which the respondents use them in design.

Several of the questions were difficult to write in a simply quantifiable form so they were written open-ended. This has necessitated a textual analysis, with no statistics or percentages, just summary quotes.

Only a limited number of the questions are analysed here.

CBPR experience[4] has been that clients of simulation analysis are interested as much in issues of comfort and risk to that comfort as they are in building energy use or cost in use. 68% of the USA Survey responses referred to *bottom line costs* as the aspect of simulation that interests clients. A minority of responses referred to the "interesting" end of simulation analysis:

- *sometimes a client is interested in functional energy use with respect to occupant comfort*

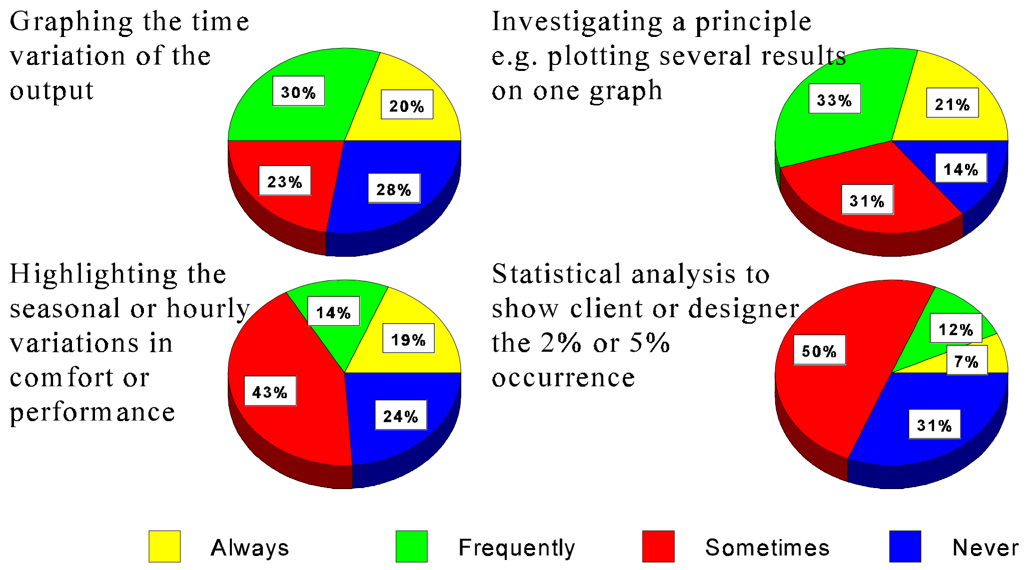

Figure 3 USA Survey: How often do you use post-processing of simulation output?

- *15% of clients are architects and [they] have an overly romantic notion of what is possible*
- *interested to the extent that if they get a law suit then a reasonable or good method has been used*

There was a wide range of responses to the questions about customisation of the simulation program output (See Figure **Figure 4**). Most people (41% *always) graph* the output data. However fully 67% never calculate *comfort indices*. The picture that arises is of a group of consultants who routinely study capital and running cost options in HVAC equipment for clients. They can do more, but they are normally not paid to.

Of the 27 who responded with reasons for customising output, 13 did so because it allowed them to do custom chart (graph) making and to enter into spreadsheets for report writing or further analysis. 8 others customised output in order to debug the model or to assist with quality control in some unspecified manner.

The questionnaire also sought to understand whether simulationists felt the need to explain to their clients the nature of the relationship between reality and their one-time analysis for one particular “year” of weather data. Clients often want performance guarantees that simulation cannot provide without further analysis of the output and input data. 43 people responded to this question. Only 4 *Never* had

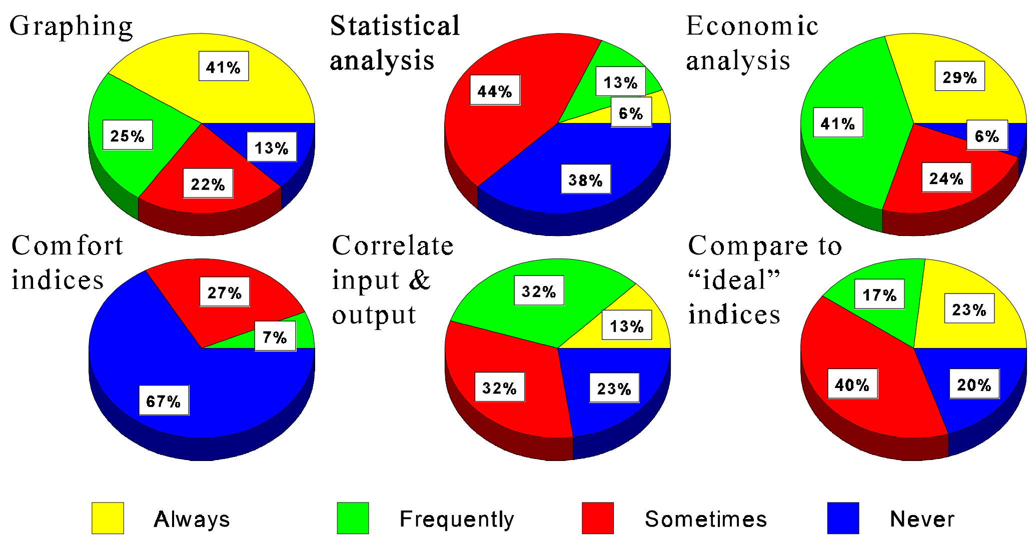

Figure 4 USA Survey: Frequency of use of customisation of output from simulations

to *interpret the results [of simulation] to assist [clients] to understand or use them appropriately*. 26 (60%) *Always* or *Frequently* had to do this.

The final question about customisation related to the rationale behind customisation of output. The question pointed out that often simulation output is trivialised by being reduced to one single data point - a lone energy performance figure expressing the annual energy use of a building design. Participants were asked how often they used one of four techniques to incorporate into their design reports the *rich availability of data typically produced by simulation?* The four techniques were *graphing the time variation* of the output, *highlighting seasonal or hourly variations* in comfort or performance, *plotting several results on one graph* to investigate parameter interrelationships, and *statistical analysis* to show say 2% or 5% occurrences of conditions. The responses to this question are shown in **Figure 3**.

Graphing of the output is the most consistently used post-processing method used by participants. Both the first two options described types of graphical analysis: *Simple graphing* of the output is *Always* or *Frequently* used by 50% of the participants. *Post-processing in order to demonstrate a principle by say plotting several simulations on one graph* is used *Always* or *Frequently* by 50% of the participants.

Statistical *analysis* of the output or *formatting the design report to highlight the seasonal or hourly variations of comfort or performance* are rarely performed.

The *Quality Control* processes the participants used to ensure that the simulation software produces reliable results were investigated further. Each question sought feedback from participants on what techniques they used in simulation modelling to ensure that they created efficient but accurate models of reality.

The questions were open-ended because too little documentation of Quality Control procedures existed to permit creation of a useful set of categories for analysis of the answers. 40 of the USA Survey participants responded to this question. Two of the responses were that the respondents had no formal QA procedures. All the telephone interview respondents commented that they had no formal QA procedures.

Special note was made that there were no written procedures that the participants could provide as examples. While all admitted they had no formal documented procedures most described some form of organised scrutiny.

The largest group of respondents used various other calculations to measure the simulation output. Rules of thumb, libraries of systematic simulation *studies of a range of buildings in different climates for policy development purposes*, spreadsheets *based on other methods* are all used as standards against which to measure the output of their simulations of building performance. The following comments demonstrate what these respondents do:

- *Rules of thumb*;
- *generated a bunch of tables using typical building for 15 building types and 8 climate zones - have from this a 2cm thick set of tables showing x building: y zone: z energy measure: versus yields*;
- *we have routines that collect underheated hours - synopsis of these for 100-300 zones shows errors*

The next largest group of participants (32%) reported that their form of Quality Assurance is to *eyeball* the data. Statements like *reality checks* and *we graphically review our data* abound. Typical of this group are comments like:

- *engineering judgement*;
- *scrutinise the output (e.g. hourly values) to check behaviour - does it look logical or reasonable*
- *eyeball the demand on say the coil - if greater than or equal to the load then check;*
- *sanity checks - experience tells you whether x per square foot is OK.*
- *intuition, though unreliable when results not intuitive, is used.*

There was also a considerable number of people (22%) who compare their simulation model with monitored data for the building they are modelling. These people are involved in energy conservation studies of existing buildings and are using simulation to study equipment options for the refurbishment.

A further question addressed the means of communication between the simulationist and the other members of the design team. It sought to match their office procedures to 7 modes of operation and communication, ranging from electronic data exchange to regular formal design team meetings.

The results seem to indicate that the most common modes of working are the standard modes of the individual firm working as consultants to the building design team and communicating with them through regular meetings and exchange of (paper based) drawings. Only a few people saw *Electronic drawing exchange* - matching *Exactly* (15%) or *Fairly well*

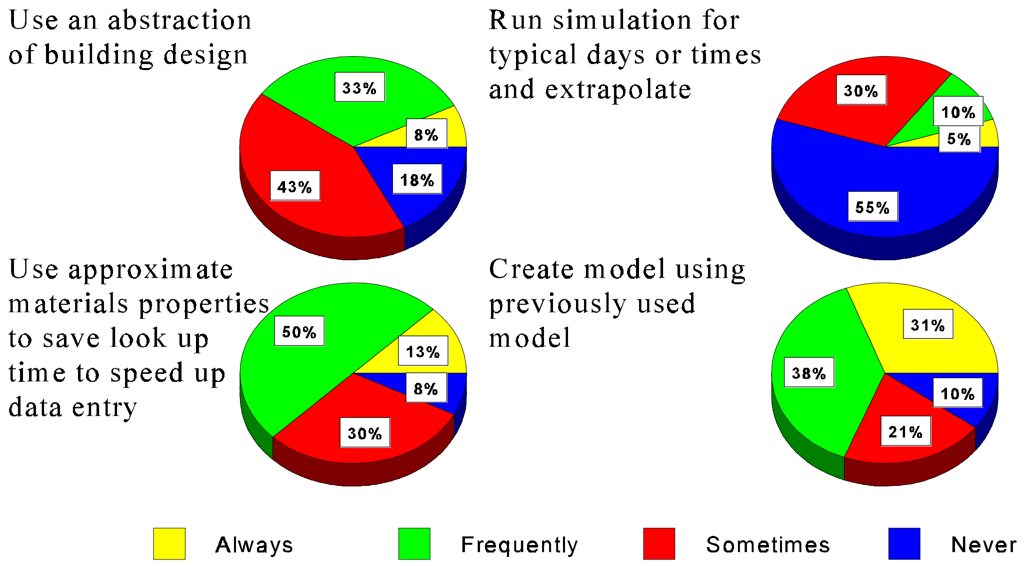

Figure 5 USA Survey: How often did you use one of these techniques to expedite the process of creating a simulation model

(20%) their mode of working. Formation of *project design teams* by amalgamating personnel from several different practices in one office, or just membership of a *multi-disciplinary firm* are both rare. Also rare are *weekly* or *daily* team meetings.

There is nothing in any of these answers to point to any major degree of innovation in the mode of working. There is nothing also that demonstrates a likelihood that computer software developments assisting electronic communication between firms fits well with the way that these firms want to work.

A final question on Quality Assurance addressed a set of four very different options which were described at length. The participants were asked to select from the list techniques which they used to *expedite the simulation process and thus provide the design team with timely answers.* The options offered were:

- *Use an abstraction of the building design as a first approximation (say a one zone building in thermal design - or roughly equivalent opening areas, with no window details in daylight design);*
- *Run the simulation for typical days or times that enable you as expert user to interpret the full year or inter seasonal performance;*
- *Used approximate materials properties or library values that are close to but not the same as those specified to speed up data entry;*
- *Modify previously used model.*

Three of these techniques are used *Frequently* or *Always* by most of those who responded to the question. 55% of them report that the fourth technique - *running the simulation for typical days or times* is something they *Never* do. In the past this was a common technique because the calculation time for the actual simulation was several hours. It is apparently less necessary now because the computational time for the computer simulation has shortened with recent increases in computer speeds. What takes the time now is the creation of the simulation model itself.

Both questions asking participants what improvements they would like in their simulation software were open-ended questions. Again, the goal was to extract information on users' needs and desires for software improvement without feeding them the answer(s). The purpose of the second question on the topic was to elicit the priorities the participants had for the changes they were suggesting as well as generating a "laundry list" of changes. The questions therefore asked first *what changes or improvements [participants] would like to see in the* building performance simulation software; then they asked what *single improvement* participants would like to see in the software.

17 of 42 (40%) respondents' answers suggested improvements were required to the User Interface. A Graphic User Interface (GUI) with windows and mouse control was most often suggested. When asked to prioritise a single change, 27 of 38 (71%) respondents placed a GUI at the top of their list. There was no general agreement on how the user interface might be better improved as this selection of

comments indicate ("list" refers to comments from the list question and "priority" to comments from the question seeking participants' priority for a single improvement)

- *more friendly to the user* (list)*; - user friendly interface* (list)*;*
- *make the reference material more accurate and simpler to understand* (priority)*;* and *most documentation stinks - vast improvement possible* (list);
- *better visual link to the building shape / configuration* (list); *ability to extract data from CAD drawings* (priority); and *easier to model buildings in schematic design phase;*(list)
- *customised defaults and schedules* (priority); and *different levels of simulation for different stages of design;* (list)
- *self checking routines to flag HVAC system errors;* (list) and *more descriptions with libraries so when call out a system or plant pull out whole text description of file;* (list)
- *I would like it to be easier to determine the interrelation of an input in one area of the program on the calculations in other areas;*(list) and *error checking of interaction of components - e.g. warnings of things that don't make sense together;* (list)
- *I would like [all programs I use] to ... know me and the way I work - from data entry to format of help file: if I start repeating a process, I want the program to assist* (to anticipate); (list) and *BDL writers currently will produce a new bdl file well, but when you make changes they have problems;* (priority)

The other significant group of respondents sought changes in the modelling capabilities of the software. The suggested changes ranged from improved physics to additional models of components. An attempt was made to group the suggested changes in modelling capability to ascertain what was collectively viewed as important:

- building physics changes such as *a better ground coupling algorithm* (priority); and *better "passive solar" or heat storage of various building materials* (list);
- additional building model features such as: *air transfer between zones* (priority)*;* and *relation between air infiltration and system air movement;* (list)
- additional plant modelling capabilities such as: *keeping up with new technologies especially on the air system side*(list); and *direct modelling of ground source heat pumps* (priority);
- better modelling of control systems: *accurate modelling of control strategies and sequences* (list)*;* and *a simple way to model part load performance;* (priority)

(None of the other suggested changes could be organised into groups bigger than 7 (18%).

Even the individual responses reveal some intriguing insights:

- *Get support group privatised - working for us the users. Lot of government sponsored work on program is making new models rather than making what is there work better (without holes). ..Half our costs are in working on the 10% or the program that does not work well... Users don't have a say in what the support group does* (priority)
- *Integrated Quality Control and Help reference.*(priority)
- program requires a *cumbersome non-intuitive way of working* [due to].*its data structure: e.g. specify fan/chiller in four different places; simulation engine suffers through being written by scientists and engineers;*

CONCLUSIONS

The analysis of all 52 NZ Survey and 51 USA Survey questions is still incomplete. The questions that have been analysed in this paper have been those concentrating on the interface between the user and the simulation program. The conclusions are all relevant to the development of new interfaces for simulation packages.

All users of simulation programs are looking forward to improved GUI interfaces to their design tools. However, they have all adopted a number of procedures and techniques in their general practice which these GUI developments do not currently support. In order to support the way these experienced users work, a number of graphing tools and tools for ensuring Quality Control are required.

If the planned GUI improvements are as successful as with other programs like Word Processors in encouraging many more users then it is clear from these results that Quality Control and graphing tools in particular are absolutely essential. In order to avoid the "garbage in garbage out" syndrome, with these new users, it is essential that these new and inexperienced users be provided with:

- tools to expedite the entry of a building description;
- tools to ensure that the climate model used is appropriate to the design situation;
- tools to ensure that the building description is an accurate model of reality;
- tools to ensure that the relationship between data input and performance can be studied systematically;
- tools to permit the communication of the building performance to clients.

ACKNOWLEDGEMENTS

This research was conducted while the author was on Research and Study Leave at Lawrence Berkeley National Laboratory from Victoria University, Wellington, New Zealand.

The work reported here could not have occurred without a number of persons' assistance. I would like to make special mention of: the Centre for Building Performance Research, and especially its Manager at the time of this research Nigel Isaacs. I would also like to extend my thanks to Dr Selkowitz and his colleagues at LBL in Berkeley for their kind hospitality and guidance. Victoria University, the Energy Efficiency and Conservation Authority and the Building Industry Authority provided much needed resources. And finally, the research assistants, Mr Chris Watson and Ms Jacky Lee provided much-needed insight into the survey and analysis practicalities.

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